Observer Reliability Using

The NUCCA Spinographic

Analysis System

by

Daniel C. Seemann, Ph.D.

Associate Professor, University of Toledo

Research Advisor to the National Upper Cervical Chiropractic Association

December, 1982

Abstract

The acceptance of spinographic analysis as an accurate measurement system has been suspect especially with regard to the reduction of the subluxation. The problems of magnification, distortion, and observer error can be solved by properly aligned x-ray, patient placement and competent observers. The results of this investigation show that a very high rate of consistency can be demonstrated between and among observers.

Key Words: biomechanics, spinographic analysis, magnification, distortion, reliability coefficient, chiropractic, cervical, x-ray alignment.

Observer Reliability Using
The NUCCA Spinographic
Analysis System

The use of x-rays as a diagnostic tool has been helpful in locating pathology and structure in the anatomical frame, but the use of spinographic analysis to evaluate biomechanical relationships where precision in the measurement is required, has had mixed reception. Hildenbrandt[1] noted that critics of spinographic analysis contend that too much latitude has been taken with the analysis without putting the programs to scientific scrutiny. Philips[2] summarized some of the major problems with spinographic analysis to be: 1) technical error due to magnification and distortion, 2) observer error, and 3) basic marking errors with line drawings. As a result of these criticisms, the acceptance of spinographic analysis as an accurate measurement system has been suspect, especially with regard to the reduction of the subluxation.

The purpose of this study will be to show that the technical problems of distortion can be controlled by the proper alignment of x-ray equipment and patient placement. It will also show measurement problems caused by magnification can be solved by using a rotatory measurement system rather than a linear system. The investigation will also attempt to show that a high level of inter-observer and intra-observer reliability can be demonstrated when the technical problems stated above are solved and the technical competence of the observers are of good quality.

There are five hypotheses that will be investigated in this study. Hypothesis #1. An observer will analyze the same set of x-rays over a period of time. The question: Will there be a difference between the first analysis and the second analysis over a period of time? (intra-rater reliability)

Hypothesis #2. Several observers will analyze duplicate x-rays taken of the same patient, at the same site. The question: Will there be observer differences analyzing the same x-rays? (inter-rater reliability)

Hypothesis #3. Two observers will position and x-ray the same patient, at the same site. The question: Will there be differences in the x-ray analysis because of the two observers positioning the same patient at the same site?

Hypothesis #4. Two observers will position and x-ray the same patient at different sites. The question: Will there be differences in the x-ray analysis because of the two observers positioning the same patient at two different sites?

Hypothesis #5. Three observers will analyze the x-rays of the same patient taken at different sites. The question: Will there be differences in the analysis because of the two observers positioning the same patient at two different sites?

The null hypothesis will be assumed with all five hypotheses: that in fact, there will be no differences among and between observers. The prediction is that the reliability coefficients (RC) will be high among and between observers.

Alignment of X-ray

In order to secure quality x-rays, several components of the x-ray equipment must be aligned properly. The procedure is relatively complicated and most x-ray suppliers are not trained to align the equipment properly. The responsibility then becomes the problem of the practitioner. Dickholtz[3] in his brochure *X-ray Alignment,* outlines the procedures necessary for proper alignment. Proper alignment requires that two planes be established in such a way that all units of the x-ray equipment are precisely 90 degrees to each other. On the long axis, the exact center of the bucky, the film, the object, the head clamps and focal spot should bisect this plane (see figure 1).

The short axis is set at 90 degrees to the long axis and the main tracks of the x-ray. The tube arm, x-ray head, bucky and the head clamps are set at right angles to the long axis and the main tracks of the x-ray (see figure 1).

Patient Placement

The other factor that contributes to x-ray distortion is improper patient placement. If the patient's head is not placed precisely 90 degrees to the focal spot, the side of the head that is nearest to the ray, will appear larger and the radius of the head will shorten and appear flatter on the side of head furthest from the ray. Analyzers sometimes perceive these differences as a bone or tissue anomaly. In upper cervical analysis, for example, a condyle which is viewed as short enlarges after an adjustment and appears the same size as the other condyle because the condyle is now the same distance to the focal spot as the other condyle (Gregory[4]).

Hildenbrandt[5] recommends that patients be x-rayed in the vertical position because the effects of gravity are different when viewed in the horizontal position. NUCCA agrees with this notion. Pressure on the spinal column in the standing position ranges from 190-300 lbs. per square inch. Pressure reduces to 30 lbs. per square inch in the supine position (Seemann[6]). The anatometer studies showed that the short leg in the supine position was not the same length when measured in the vertical position, because part of the leg shortness was shifted to rotation and pelvic tilt. Therefore, to x-ray a patient in the horizontal position artificially "corrects" rotation or tilt and precludes an accurate view of biomechanical relationships in the film.

With upper cervical analysis, the patient is seated in a chair that is permanently fixed to the floor, but can be rotated 350 degrees, move anterior/posterior to the bucky, and move lateral to the bucky. When taking the nasium film, the glabella is centered to the center of the bucky and film. If the head is tilted in the lateral plane, the tilt is not removed. If the head is rotated, the patient's body is rotated until the head is in a 90 degree plane to the bucky. Both tilt and rotation are a part of the patient's subluxation and to remove them manually would cause an error in analysis.

A scissors type head clamp which is fastened to the bucky is placed on either side of the head at the ear level. The head clamp is aligned so that the center of the head clamps always bisect the center of the bucky. The head clamp then acts as a centering device which assures the head will always bisect the center of the bucky. The head clamps also assure that the head will not move during the exposure. Vertex and lateral views are taken in a similar manner and further information about head placement can be found in Dickholtz[7]. All films are taken at 42 inches focal spot to the film and all NUCCA instruments are designed to measure x-ray images at the 42" distance.

The Rotatory Analysis

The NUCCA system[8] is based on rotatory relationships between the frontal, sagittal, and transverse planes of the atlas, the head and the lower cervical units (C2 - C7). In the frontal plane (nasium), there are four relationships that are calculated to determine part of the reduction pathway. The first, is the relationship between the position of the head and the atlas. The relationship is called laterality and is measured in degrees. If the head has tilted to the right from the vertical axis and the angle is less than 90 degrees to the atlas plane line, the patient has a right laterality. Laterality is the most important element because it determines which side the head is placed for the adjustment (contact), (see figure 2). With the second relationship, the analyzer needs to know if the axis has rotated to the same degree as the atlas and this can occur three ways: (1) the atlas and axis misalign to the same degree, (2) the axis misaligns to a greater or lesser degree, and (3) the axis misaligns to the opposite frontal plane. The third relationship requires the analyzer to determine the ratio between the condylar and axial circles. The condylar circle is determined by the length of the arc of the condyles. The length of the arc determines the number of degrees the head can turn on the condyles. The axial circle is determined by the width of the base of the superior aspect of axis. The degree to which the lower cervical units (C2-C7) can rotate in relationship to the atlas is dependent on the width of the axis. The size of the two circles is a factor in reducing the subluxation. The larger the size of the axial circle in relationship to the condylar circles, the greater the leverage required in the adjustment (see figure 3). The fourth element examines the relationship between laterality and the lower cervical line which is drawn downward from the atlas plane line at a point which bisects the centers of the odontoid process and the spinous process of axis to the body center of the seventh cervical vertebra. There are four combinations that can occur: (1) laterality is smaller and opposite to the lower angle, (2) laterality is larger and opposite to the lower angle, (3) laterality is smaller and on the same side as the lower angle, and (4) laterality is larger and on the same side as the lower angle. When laterality is on the opposite side of the lower angle it is called "opposite to the kink" or Type 1. If laterality is on the same side as the lower angle it is called "into the kink" or Type 2 (Gregory[9]). (See figure 4 & 5).

With the vertex film the relationship between the head and the atlas is established by drawing a line that bisects the skull A to P and to a line that bisects the atlas. If these lines are not parallel or collinear, the atlas is considered to have rotated either anterior or posterior to the skull depending on the side of laterality (see figure 6).

The four elements from the nasium film combine to form a linear value which is transformed into a height vector. This is the pathway which would be required to reduce laterality back to the vertical axis. The degree to which the atlas is rotated in the transverse plane is also given a linear value and this is called the rotation vector and is the path required to move the atlas back to the vertical axis in the transverse plane. In most subluxations, laterality and rotation are present and require simultaneous reduction. A single reduction pathway is determined using the Pythagorean theorem. The two elements, rotation and the height vector, form the sides of a right triangle. The hypotenuse of these two sides forms the horizontal resultant or the reduction pathway necessary to reduce the rotation and laterality simultaneously. If a force is directed precisely along this resultant, both elements will return to the vertical axis (see figure 7).

Problems with Magnification

Using a rotatory measurement system eliminates problems that a linear analysis system has with magnification, because the angle relationships remain constant. Magnification cannot alter the angle ratios between the various elements, regardless of the magnitude of the magnification (Luster & Keats[10]).

Another advantage is magnification tends to increase outward in all directions from the epicenter of the film (Hildenbrandt[5]). With the NUCCA analysis, the focal spot is centered on the atlas and the analysis is then made from the center of the film. Basically all analyses are performed from the center outward whether it is locating structures of the skull or forming angle relationships. These procedures tend to reduce errors that might occur where the analysis originates at the periphery of the film.

The third advantage of a rotatory measurement system is that asymmetrical boney structures are not a factor in measurement because in determining the relationships between the various planes in the upper cervical area, peripheral boney structures are never used in establishing a plane line. Points that are used in establishing plane lines are found near the epicenter of the film and are seldom anomalous.

Observer Reliability

Implicit in this lengthy discussion is, if the problems that are attendant with distortion, patient placement, measurement, and magnification are not controlled, then any attempt to judge observer reliability would be fruitless. Philips[11] found when he compared three different analyses there was little observer reliability. Explicit then is the assumption that consistent observation, agreement between observers and agreement within observers, is only possible if the above mentioned problems have been solved. Therefore, consistent agreement between and within observers should indicate that it is possible to utilize a spinographic system that can evaluate biomechanical relationships effectively.

Methods:

Hypothesis #1 & #2

Participants

Ten sets of pre x-rays were taken at random from a NUCCA practitioner's files for the analysis. Of the 10 patients selected, 8 were adults and 2 were young adults; 9 were females. Patient numbers ranged from 1802 to 5827 spanning a period of several, years.

The observers in the study were 5 experienced NUCCA practitioners engaged in private practice. Number of years in practice ranged from 1 year to 42 years. The practitioners are located throughout the U.S. and Canada.

Apparatus

The original set of 10 x-rays were all taken on the same x-ray equipment, manufactured by Borg-Warner. The films were taken at KVP=90 with MA=15. For the nasium view, the exposure time was 1-1.25 seconds, and for the vertex view, the exposure time was

2-2.5 seconds. The focal spot to film distance was 42 inches. The focal spot aperture was 2.5 mm. The screens used for the nasium and vertex were lightning speed. Kodak x-ray blue brand film was hand processed. The head clamp was made by Utterbach and the x-ray tube was made by Picker.

Procedure

A total of 50 sets of films were duplicated after the line drawings of the original sets were erased. Each of the five observers received the same set of 10 x-rays for the analysis. A set consisted of a nasium and vertex view.

For the inter-observer study, the 5 observers were asked to analyze each of the 10 sets of films, at their respective offices. After reading and analyzing, the films were returned to the investigator. The observers were blind as to what data would be used in the study. They were told that the investigation was concerned with observer reliability.

An intra-observer study was conducted with 2 observers. They were asked to re-analyze the films that they had analyzed in the inter-observer exercise. The investigator erased the line markings from the first set of films and after a period of about one month asked the 2 observers to reanalyze the films. The Pearson product-moment of coefficient of correlation was used in the analysis of the data of both the inter- and intra-rater data.

Hypothesis #3

Participants

Ten patients were used for this part of the study. All were new patients and they were not known to the observers. There were all adults, three females and seven males. X-rays were taken over a period of approximately three weeks. The two observers were experienced practitioners.

Apparatus

The equipment was used as in hypothesis #1 and #2.

Procedure

Normal procedure for x-raying a patient in this particular office was to take a lateral, two nasiums and a vertex. For the study, a lateral, two nasiums, and two vertexes were taken. Observer #1 took the lateral, a nasium, and a vertex. Observer #2 then repositioned the patient and took another nasium and the vertex.

Observer #3 analyzed the two sets of ten x-rays blind as to which set was taken by Observer #1 or Observer #2, Observer #3 analyzed the film sets in random order.

Hypothesis #4

Participants.

Nine regularly accepted new patients were used in this part of the study. All of the participants were were briefed as to the goals of the study. It was important that the participants were fully compliant because they were required to be x-rayed at two different locations by two different observers. The participants were x-rayed over a period of approximately five weeks.

The observers were experienced practitioners with their offices located approximately 20 miles apart.

Apparatus-Observer #1

The x-ray equipment was a Jamaica Brand, Westinghouse 200/100;
film, RPI AGFA GAVENT; screens, DuPont Quanta III; time, t=MAS/MA. The film was processed by PACO and the grid ratio was 5:1.

Apparatus-Observer #2

The x-ray equipment was a Trans World machine; film, Kodak Blue Brand 1; High Plus Screen; 12:1 grid ratio; time, with females, nasiums were taken with 50 MA, 2/5 sec and 92-96 KVP, vertexes were taken 100 MA 2/5 sec, 96 KVP; with males, nasiums were taken 50 MA, 1/2-3/5 sec, 94 KVP, the vertexes were taken at 100 MA, 1/2-3/5 sec, 96 KVP.

Procedure

A vertex and a nasium were taken of each participant at each location. The participants were x-rayed on an available basis, therefore, it was not always possible for Observer #2 to take x-rays of the participant the same day as Observer #1. The participants were not under chiropractic treatment at the time of the study. The Observers were asked not to discuss the listings of the participants during this phase of the study.

Observer #3 analyzed the nine sets of film taken by Observer #1 and #2. The films were analyzed in random order and Observer #3 was blind as to which films were being analyzed.

Hypothesis #5

Participants

The films of the participants used in Hypothesis #4 were used in the analysis.

Procedure

Observer #1 and #2 analyzed the nine sets of x-rays that they had each taken for Hypothesis #4. These listings were taken and compared with the listings found by Observer #3.

Results

The Observers who participated in the study were trained in the NUCCA system of spinographic analysis. Therefore, the following results can only be generalized to practitioners who use the NUCCA analysis system.

The height vector was used as one element of the analysis because the height vector is a total of four relationships discussed earlier. The other element, the rotation vector, was used in determining the other side of the reduction pathway.

The investigator disqualified one set of films on the grounds that the nasium film was too difficult to read. The posterior ring of atlas where the ring crosses the lateral masses was not clear and under most conditions, the patient would have been re-x-rayed.

Table 1 shows the Reliability Coefficients (RC) for the Intra-Observer study with Observer #1. Comparing the first rotation analysis with the second, the RC is 0.97. Comparing the first height vector with the second, RC is 0.94. The average RC is 0.96. The average deviation per set is 0.54 degrees for rotation, and 0.52 inches for the height vector.

Table 2 shows the RC for the Intra-Reliability study with Observer #2. comparing the first rotation analysis with the second, RC is 0.98. Comparing the first height vector with the second, RC is 0.99. The average RC is 0.985. The average deviation score for rotation is 0.42 degrees and for the height vector, 0.25 inches.

Table 3 shows the RC between the 5 Observers with regard to the rotation vector. The standard used in the comparison is Observer #1. The highest RC is between Ob #1 and Ob #5, which is R=0.99, the lowest is between Ob #1 and Ob #2, which is R=0.81. The mean for the Ob #1 column is R=0.93. The lowest correlations are found in column Ob #2 between Ob #2, Ob #3 and Ob #4, which were, R=0.58 and 0.67 respectively.

Table 4 shows the RC's between the 5 Observers for the height vector. Again the standard used in comparison is Observer #l. The highest coefficient is between Ob #1 and Ob #5, which is R=0.99. The lowest correlation is between Ob #1 and Ob #2 in column #1 which is, R=0.87. The lowest coefficient across all Observers is 0.80 between Ob #2 and Ob #3. The mean for Ob #1 is 0.90 and the grand mean is 0.93.

Table 5 shows the inter-rater reliability between the two different observers who positioned the same patient at the same site. The RC between the two sets of rotation listings is R=1.00. The RC between the two sets of height vectors is R=0.993.

Table 6 shows the inter-rater reliability between the two observers who positioned the same patient at two different sites. The RC between the two sets of rotation vectors is R=1.00. The RC between the two sets of rotation vectors is R=1.00. The RC between the two sets of height, vectors is R=0.99.

Table 7 shows the inter-rater reliability of three observers who analyzed the same film of the same patient who was positioned at two sites, by two different observers. The RC of the height vectors between Observer #1 and #3 is R=0.90. The RC between Observer #2 and #3 is R=0.80.

Table 8 shows the inter-rater reliability of three observers who analyzed the same film of the same patient who was positioned at two sites, by two different observers. The RC of the rotation vectors between Observer #1 and #2 is R=0.80. The RC between Observer #1 and #3 is R=0.93. The RC between Observer #2 and #3 is R=0.806.

Discussion

The goal of this research was to demonstrate that spinographic analysis can be a viable tool in analyzing biomechanical relationships. By presenting five different conditions, the problems of magnification, distortion and observer error were examined either as an entity or as a part of another variable. For an example, in Hypothesis #1 the concern was intra-observer error. Can the observer be internally consistent in how they analyze x-rays? The results suggest that this is possible. Another concern was inter-rater reliability. Can a group of analyzers obtain the same results reading the same x-rays? Hypothesis #2 indicates that a high inter-consistency can be realized. The observer error is reasonably well answered but what about the magnification and distortion problem?

Hypothesis #3 and #4 answer the distortion problem. #3 examines the consistency of two observers placing and x-raying the same patient using the same x-ray equipment, #4 examines the consistency of two observers placing and x-raying the same patient using different x-ray equipment. One might expect the (RC) to be higher for #3 because of the variance due to equipment and time placement of the patient is controlled, but the high consistency found with #4 realizing that there were equipment differences and considerably more time lag from one observer to the other is particularly impressive.

Hypothesis #5 attempts to answer the magnification problem, which is an analysis problem, because if there is high consistency among three observers analyzing two different sets of films taken at two different sites, most of the variables that would work against a reliable spinographic analysis would be present. The evidence shows that there can be a successful interchange of films without too much loss to the patient. The standard used in this study is based on two criteria. Downie and Starr[12] indicate that reliability coefficients (RC) of over 0.90 are extremely high. Therefore (RC's) of 0.90 or better suggest a high consistency, approaching unity. The differences between observers in the majority of the cases in this study were very small therefore supporting the null hypothesis predicted for this research. The investigator feels that coefficients above 0.90 are an acceptable standard, because this index translated into slightly less than one degree of variation each time an observer analyzed a film. This small an error would not be detrimental to a patient except where the error would change laterality or side of the rotation. It is also doubtful that the adjuster could make an adjustment of a half of a degree to his body posture to accommodate the final resultant if in fact the adjuster knew of the discrepancy.

The results also suggest there is a tendency of the observers to be less consistent with the rotation vector than with the height vector. This is a somewhat surprising finding because determining the rotation vector is thought to be a less complicated procedure than establishing the height vector.

Conclusion:

The performance of the observers supports the position that it is possible to evaluate biomechanical relationships using spinographic analysis. The key to successful spinographic analysis is properly aligned x-ray equipment, proper placement of the patient, a rotatory measurement system, and competent observers.

Acknowledgements:

The author wished to acknowledge the contributions of Drs. Ralph Gregory, Keith Denton, Teresa Denton, and Edna Denton, Monroe, Michigan; Dr. Marshall Dickholtz, Chicago, Illinois; Dr. Al Berti, Vancouver, B.C.; Dr. Lloyd Pond, Farmington, New Mexico; Dr. Glenn Gripe, Newport Beach, California, and Dr. Gordon Grannis, Laguna Beach, California.

References:

1. Hildenbrandt, R. W. The Chiropractic Spinography Issue. J. Manip Physiol Ther 1981; 4: 171-172.

2. Philips, R. B. The Use of X-rays in Spinal Manipulative Therapy. In: Haldeman, S Ed. Modern developments in the principals and practice of chiropractic. New York: Appelton-Century-Crofts 1980: 189-208.

3. Dickholtz, M. X-ray Alignment Handbook. National Upper Cervical Chiropractic Association, 1971.

4. Gregory, R. Some Comments Regarding the Concept of Normal. The Upper Cervical Monograph, April 1982: Vol.3, NO. 3.

5. Hildenbrandt, R. W. Chiropractic Spinography and Postural Roentgenology. J. Manip physiol Ther 1981, 4: 191-202.

6. Seemann, D. C-l Subluxations, Short Leg, and Pelvic Distortions. The Upper Cervical Monograph, Nov. 1978: Vol. 2, No. 5.

7. Dickholtz, M. Patient Alignment for Upper Cervical X-rays. The Upper Cervical Monograph, Dec. 1980: Vol. 2, No. 8

8. Gregory, R. The Atlas Subluxation Complex Manual. The National Upper Cervical Chiropractic Association, 1971.

9. Gregory, R. Biomechanics of the Upper Cervical Spine. The Upper Cervical Monograph, Jan. 1981: Vol.2, No. 10.

10. Luster, L. B., & Keats, T.E. Atlas of Roentgenographical Measurement. Year Book Medical Publishers, 4th Edition, 1978.

11. Philips, R. B. An Evaluation of Graphic Analysis of the Pelvis on the A-P Spine Radiograph. American Chiropractic Association Journal of Chiropractic 1975; Vol. IX:145-148.

12. Downie, N. M. & Starry, A. R. Descriptive and Inferential Statistics. New York: Harper and Row, 1977

Tables:

Table 1. Intra-Observer Reliability Coefficients for Observer #1 for The Rotation and Height Vector. N=9*

	Rotation #1	Height #1
Rotation #2	0.97	-
Height #2	-	0.94
Mean Deviation	0.54°	0.52"

*** $p < 0.01$ $r = 0.735$**

Table 2. Intra-Observer Reliability Coefficients for Observer #2 for The Rotation and Height Vector. N=9*

	Rotation #1	Height #1
Rotation #2	0.98	-
Height #2	-	0.99
Mean Deviation	0.42°	0.25"

*** $p < 0.01$ $r = 0.735$**

Table 3. Inter-Observer Reliability Coefficients for Five Observers for The Rotation Vector. N=9*

	O#1	O#2	O#3	O#4
O#1	-			
O#2	0.81	-		
O#3	0.82	0.58	-	
O#4	0.95	0.67	0.83	-
O#5	0.99	0.82	0.80	0.94

MEAN = 0.93 *$p < 0.01$ $r = 0.735$

Table 4. Inter-Observer Reliability Coefficients for Five Observers for The Height Vector. N=9*

	O#1	O#2	O#3	O#4
O#1	-			
O#2	0.87	-		
O#3	0.91	0.80	-	
O#4	0.97	0.91	0.93	-
O#5	0.99	0.86	0.89	0.97

MEAN = 0.96 *p < 0.01 r = 0.735

Table 5. Inter-Rater Reliability Patient Placement, Same Site, Same Patient, Two Observers. N=10*

		Observer #1	
		Rotation #1	Height #1
Observer #2	Rotation #2	1.00	
	Height #2		0.993

***p < 0.01 r = 0.708**

Table 6. Inter-Rater Reliability Patient Placement, Different Site, Same Patient, Two Observers. N=9*

		Observer #1	
		Rotation #1	Height #1
Observer #2	Rotation #2	1.00	
	Height #2		0.99

***p < 0.01 r = 0.735**

Table 7. Inter-Rater Reliability Two Different Sites, Same Patient, Two Different Placements, Three Observers for Height Vectors. N=9*

	Observer #2	**Observer #3**
Observer #1	0.90	0.90
Observer #2	-	0.80

***p < 0.01 r = 0.735**

Table 8. Inter-Rater Reliability Two Different Sites, Same Patient, Two Different Placements, Three Observers for Rotation Vectors. N=9*

	Observer #2	**Observer #3**
Observer #1	0.80	0.93
Observer #2	-	0.80

***p < 0.01 r = 0.735**

Figures:

FIGURE 1.

PROPERLY ALIGNED X-RAY EQUIPMENT USING THE LONG AND SHORT AXIS WIRES.

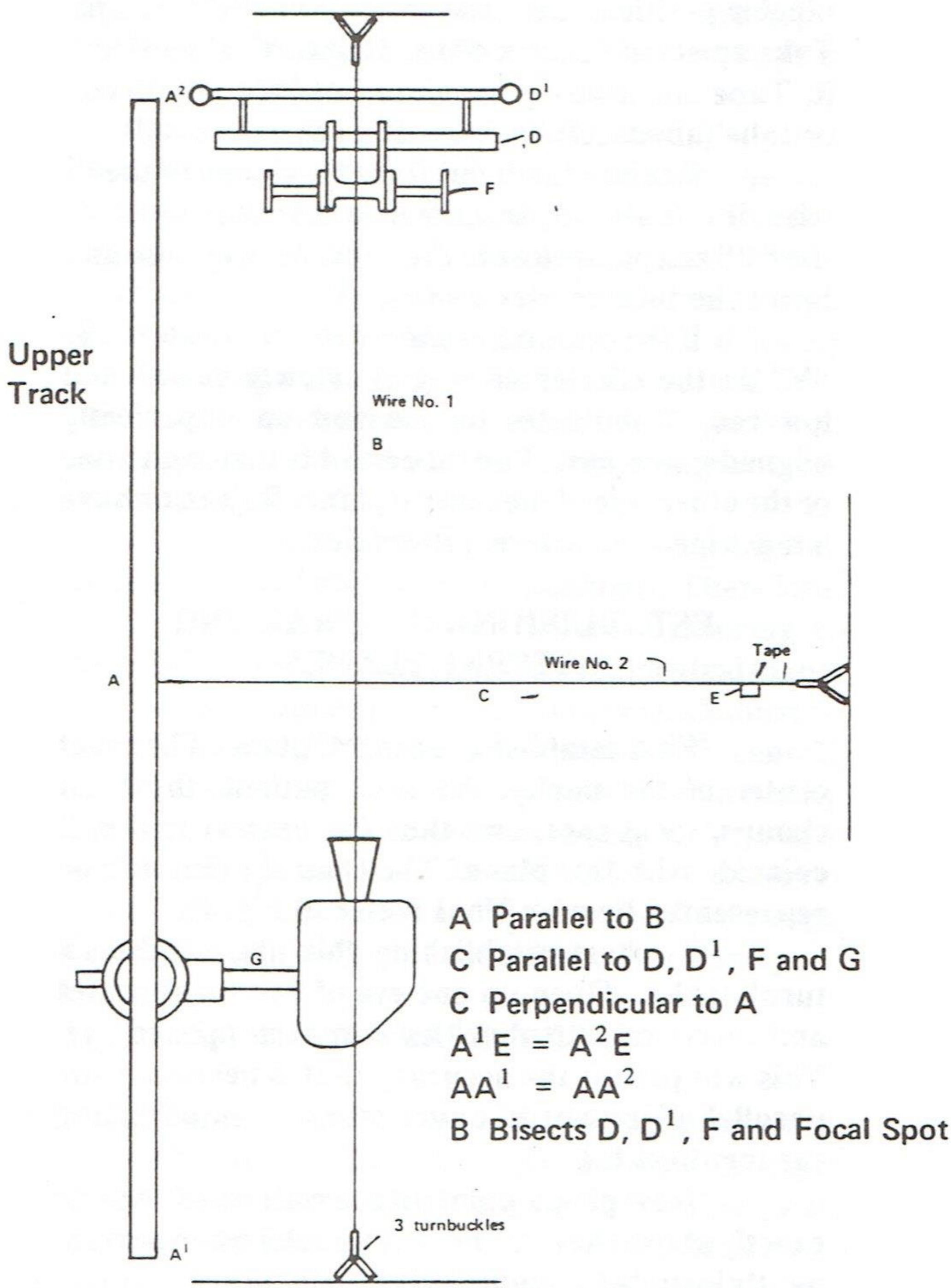
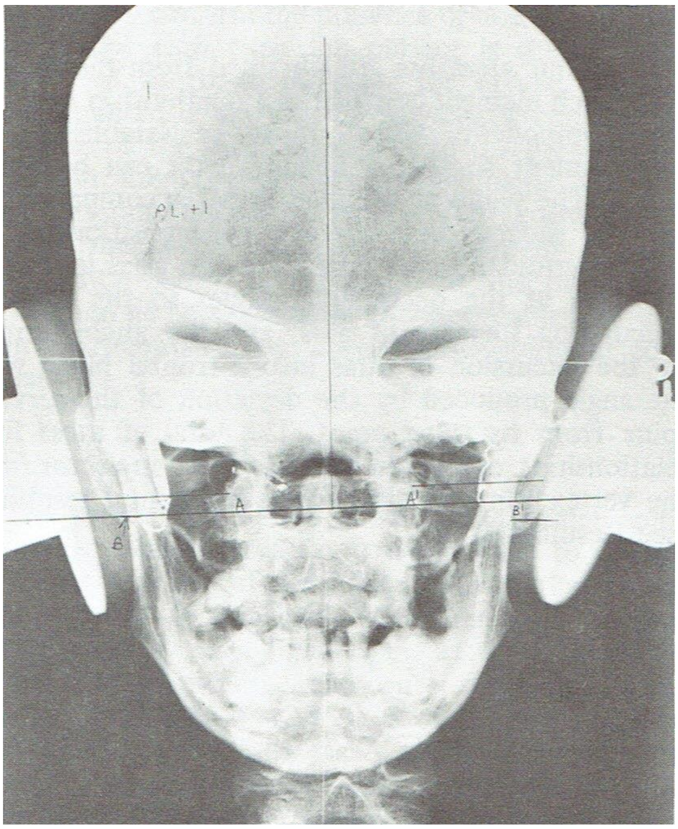


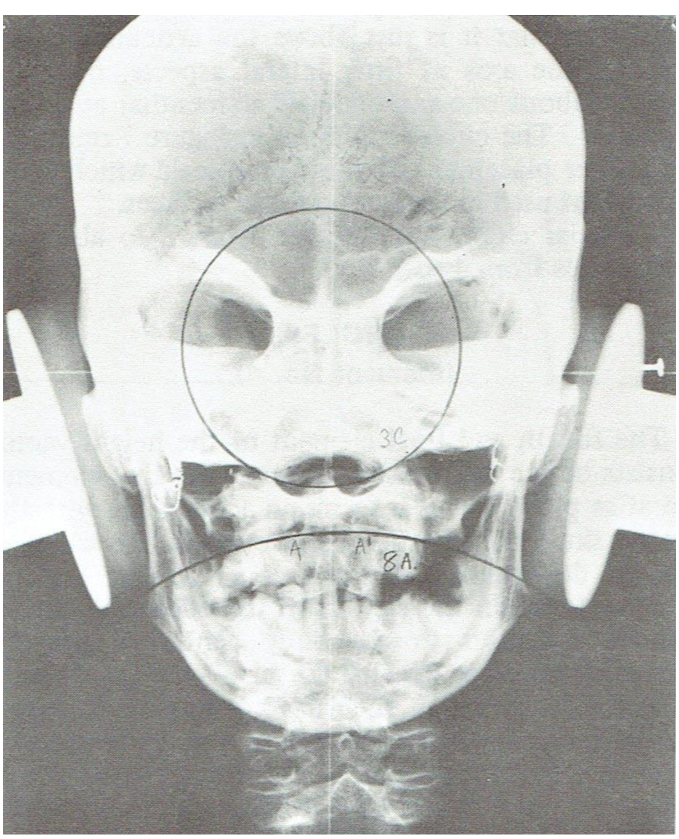
Fig. 1 — Ceiling View

FIGURE 2.



LATERALITY WHICH IS FORMED BY THE ATLAS PLANE LINE AND THE CENTRAL SKULL LINE.

FIGURE 3.



THE AXIAL CIRCLE AND CONDYLAR CIRCLE RELATIONSHIP.

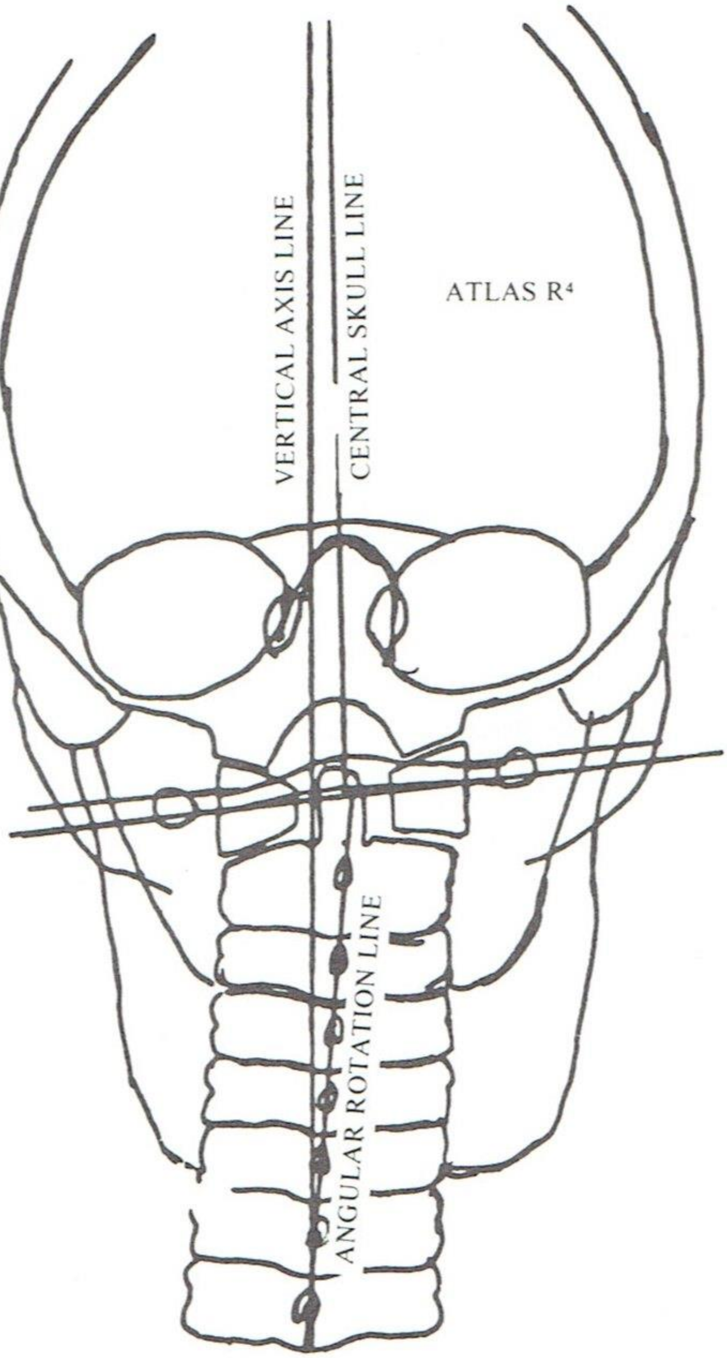


FIGURE 4.

<u>FIRST BASIC TYPE</u>

LATERALITY AND LOWER ANGLE ARE ON OPPOSITE SIDES.

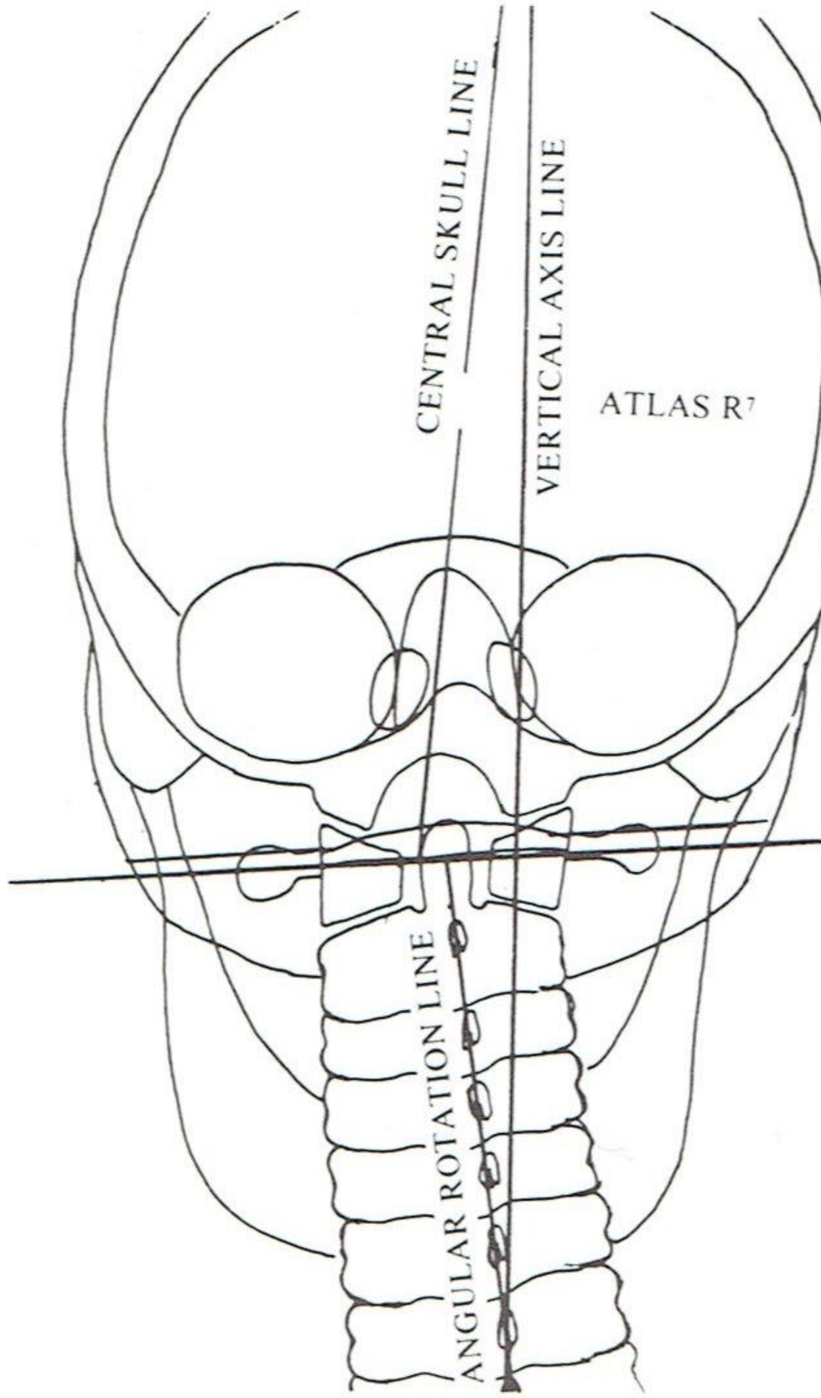


FIGURE 5.

SECOND BASIC TYPE

LATERALITY AND LOWER ANGLE ARE ON SAME SIDE.

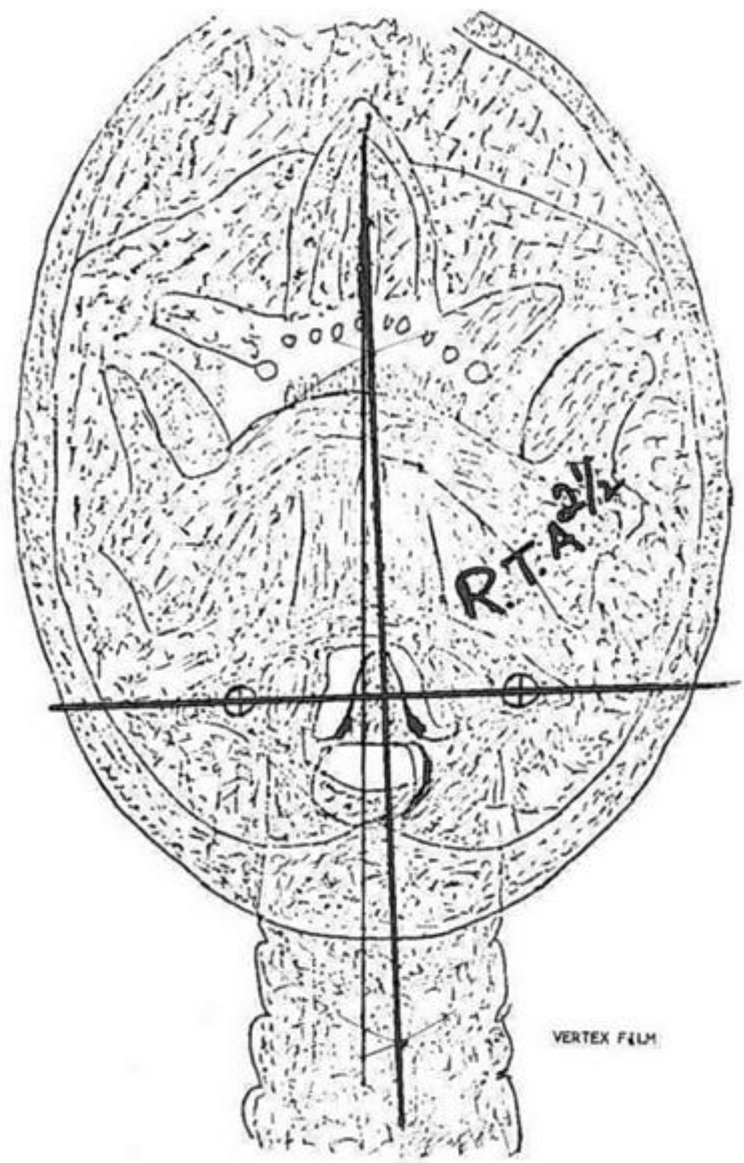


FIGURE 6.

ROTATION-THE RELATIONSHIPE BETWEEN THE HEAD AND THE ATLAS

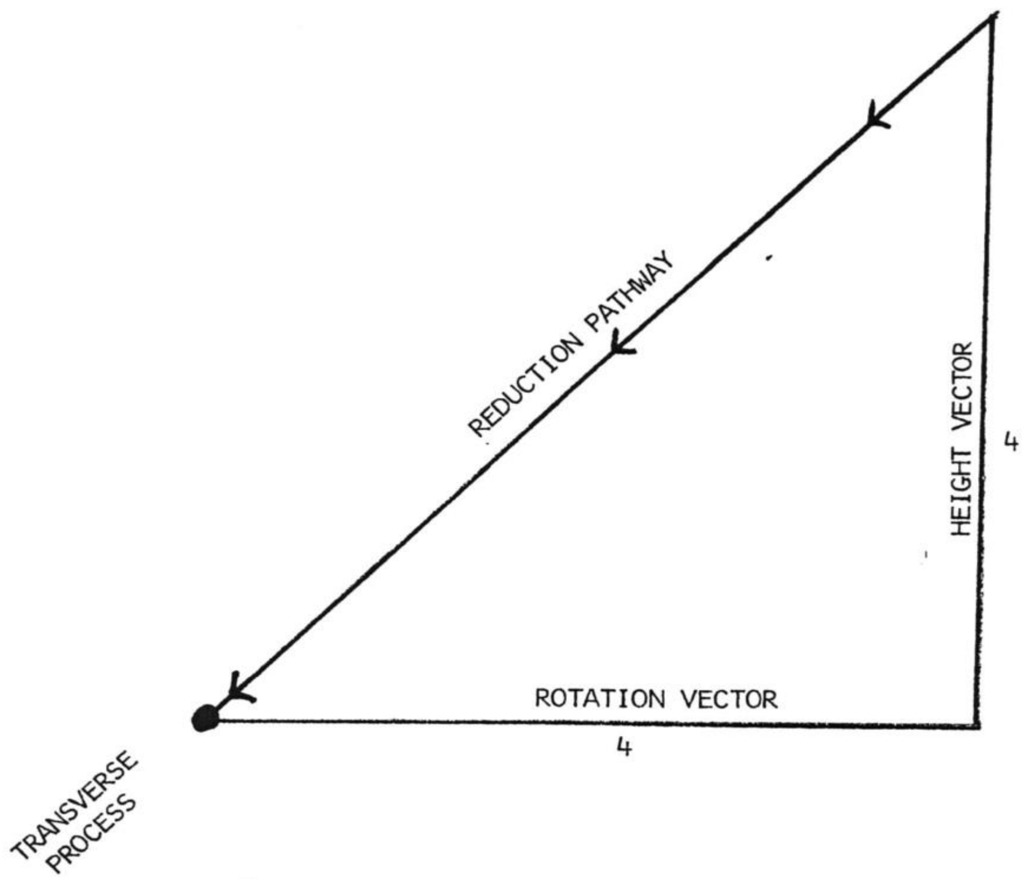


FIGURE 7.

REDUCTION PATHWAY:

THE RESULTANT OF THE ROTATION VECTOR AND HEIGHT VECTOR.